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EFFECTS OF HOLE TAPER ON MILD STEEL MACHINING USING INJECTION FLUSHING TYPE OF ELECTRICAL DISCHARGE MACHINE

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Report submitted in partial fulfilment of the requirements for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing Engineering.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Electric discharge machining (EDM) is a process for shaping hard metals and forming deep and complex-shaped holes by arc erosion in all kinds of electro-conductive materials. The effectiveness of EDM process with Mild Steel is evaluated in terms of the material removal rate, electrode wear rate and angle taper of the workpiece produced. The objective of this study is to study the effects of hole taper on mild steel machining using injection flushing type of EDM. Existing systems are generally used to produce, straight, parallel-walled holes, however there are certain application of the area exist taper holes and in the same time the machining performances also be considered. The problem of this project is improper flushing and electrode material would cause erratic cutting and poor machining rate or performance. For this thesis the influence of peak current, pulse on time, pulse off time and pressure flushing on EDM performance is discussed. The analysis of the influence of these factors was carried out by using full factorial experiment. The result of the experiment then was collected and analyzed by using STATISTICA Software. There are two level setting for each factor and the dielectric fluid is used is kerosene. The effects of hole taper on mild steel was analyzed and discussed.

ABSTRAK

Proces Pemesinan Nyahcas Elektrik (EDM) ialah proses dimana pembentukan logam keras dan membentuk lubang yang dalam dan kompleks disebabkan oleh nyahcas elektrik bagi semua jenis bahan konduktor elektrik. Proses EDM berkesan ke atas keluli besi dengan mengambil kira perkara seperti nisbah bahan terbuang, nisbah elektro terbuang dan juga sudut lubang diang ke atas material yang terhasil. Proses ini dikaji secara berterusan bagi aplikasi dalam industri pemesinan logam. Tujuan projek ini ialah untuk mengkaji kesan ke atas lubang dian bagi pemesinan besi lembut dengan menggunakan mesin nyahcas elektrik dengan kaedah suntikan bilasan. Kebiasaannya, sistem yang sedia ada menghasilkan lubang dian yang lurus dan selari dengan dinding lubang, namun ada aplikasi kawasan tertentu terwujudnya sudut pada lubang dan pada masa yang sama prestasi kadar pemesinan juga perlu dipertimbangkan. Masalah dari projek ini adalah pembilasan yang tidak tepat dan bahan elektrod akan menyebabkan kadar pemesinan yang kurang baik. Untuk tesis ini pengaruh pulsa arus elektrik, kadar masa terbuka, kadar masa tertutup dan tekanan pembilasan terhadap prestasi EDM akan dinilai. Analisis pengaruh faktor-faktor ini dilakukan dengan menggunakan eksperimen penfaktoran lengkap. Keputusan eksperimen seterusnya akan dikumpul dan dianalisis dengan menggunakan perisian STATISTICA. Dua jenis penentuan diguna pakai pada setiap faktor dan minyak tanah atau kerosin digunakan sebagai cecair elektrik. Kesan ke atas lubang dian akan dikaji dan dinilai.

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°	Degree of angle
α	Alpha
KPa	Kilo Pascal

LIST OF ABBREVIATIONS

EDM	Electrical Discharge Machining
EWR	Electrode Wear Rate
MRR	Material Removal Rate
DOE	Design of experiment
C	Carbon
Mn	Mangenese
P	Potassium
S	Sulphur
PL	Polarity
SV	Servo Voltage

CHAPTER 1

INTRODUCTION

1.1 ELECTRICAL DISCHARGE MACHINING

Electrical Discharge machining (EDM) is a non- traditional process that is used to remove metal through the action of an electrical discharge of short duration and high current intensity between the tool (electrode) and the workpiece. It also has become indispensable process in the modern manufacturing industry. It can be produced complex shapes to a high degree of accuracy in difficult to machine materials such as alloys, super alloys and carbides. While machining, there are no physical cutting forces between the tool and the workpiece (S.H. Lee, 2001).

There are two main types of EDMs: the ram (die sinker) and the wire-cut which consists of electrode and workpieces that submerged in an insulating liquid such as oil. Each are used to produce very small and accurate parts as well as large items like automotive stamping dies and aircraft body components. The largest single use of EDM is in die making. Materials worked with EDM include hardened and heat-treated steels, carbide, polycrystalline diamond, titanium, hot and cold rolled steels, copper, brass, and high temperature alloys. However, any material to be machined with the EDM process must be conductive.

EDM also the process based on removing material from a part by means of a series of repeated electrical discharges between tool called the electrode and the work piece in the presence of a dielectric fluid (C.J. Luis, 2005). Spark occurs in a frequency range from 2000 to 500 000 sparks per second causing it to appear that many sparks are occurring simultaneously. In normal EDM, the spark move from one point on the electrode to another as sparking takes place. The electrode may be considered the cutting tool. Die sinking (also known as ram) type EDM machines require the electrode to be machined in the exact opposite shape as the one in the workpiece.

1.2 IMPORTANCE OF RESEARCH

The important of research in this study are:

i. Analysis the effect of hole taper on mild steel machining by using EDM Injection Flushing.
ii. Deciding decision in order to choose best parameter of EDM performance for the result analysis.

1.3 PROBLEM STATEMENTS

In EDM machining, the existing system are generally to produce straight and parallel-walled holes. But, to achieve the straight or parallel walled holes generally there would have a neck at the end of the holes. It was because there is a larger lateral gap and also the dielectric fluid can escape through the hole exit. Thus, improper flushing and electrode material would cause erratic cutting and poor machining rate or performance. Because of that it will turn increasing machining time. Because of under certain machining condition, the eroded particles attach themselves to the workpiece and this will be effect on the machining cutting effectively and also effect on machining performance. Then it is necessary to remove the attached particles by cleaning the workpiece.

1.4 OBJECTIVE OF STUDIES

The objectives for this research are:

i. To determine the effects of hole taper on mild steel machining by using injection flushing type of EDM.
ii. To evaluate the performance of EDM mild steel with respect to various responses such as material removal rate (MRR) and electrode wear rate (EWR) on the variable machining parameter.
iii. To analysis the parameter of pulse on time, pulse off time, flushing pressure and peak current that influence EDM performance.

1.5 SCOPE OF RESEARCH

This project considers on investigating effects of hole taper on mild steel machining by using EDM Injection flushing. The research scope is limited to:

i. Sodick AQ55L EDM Die-Sinking CNC Machine is used for this research.
ii. Machining Mild Steel with 0.17% Carbon content with copper as the tool electrode using EDM machines.
iii. Parameters that be chosen for this studies includes Pulse On Time, Pulse Off Time, Peak Current and Pressure Flushing.
iv. Angle of taper that is investigates using Mitutoyo Profile Projector.
v. MRR and Electrode Wear will be calculated using mathematical formula.
vi. Design of Experiment (DOE) and ANOVA method will be processed using STATISTICA software.

1.6 RESEARCH METHODOLOGY

1.6.1 Literature Review

Proper flushing depends on the volume of oil being flushed into the gap rather than the flushing pressure. High flushing pressure can also cause excessive electrode wear by making the eroded particles bounce around in the cavity. With the pressure flushing, there is the danger of a secondary discharge. It can be occurs as the eroded particles pass between the walls of the electrode and the workpiece and will cause of side wall tapering (Reliable EDM, 2005).

B. Bojorquez, 2002 state that the most common cause of the EDM failures is inadequate flushing. The side of the mold which failed has an accumulation of residual swarf at the bottom of the machined cavity. The residue was not properly flushed, was trapped in the cavity, and reduced the gap between the electrode and so on causing the fissure and crater. It concluded that the most failures can be attributed to poor design and random occurrence. In the case of operation, low pressure and high volume of flushing work better than high pressure.

Parallel walled holes generally have a neck at the end of the hole where final drilling takes place. There is a larger lateral gap and therefore the electrode moves forward to maintain machining gap and then reaches its pre-set machining depth. The benefits of being able to control the degree of taper are improved quality, consistency of product and improved product performance due to reduced hole-to-hole geometrical variation (C.Diver, J. Atkinson, 2004).

The selection of manufacturing conditions is one of the most important aspects to take into consideration in the die-sinking electric discharge machining (EDM) of conductive ceramics, as these conditions are the ones that are to determine such important characteristics as : surface roughness, electrode wear (EW) and material removal rate (I. Puertas and C.J. Luis, 2001).

1.6.2 Flow Chart

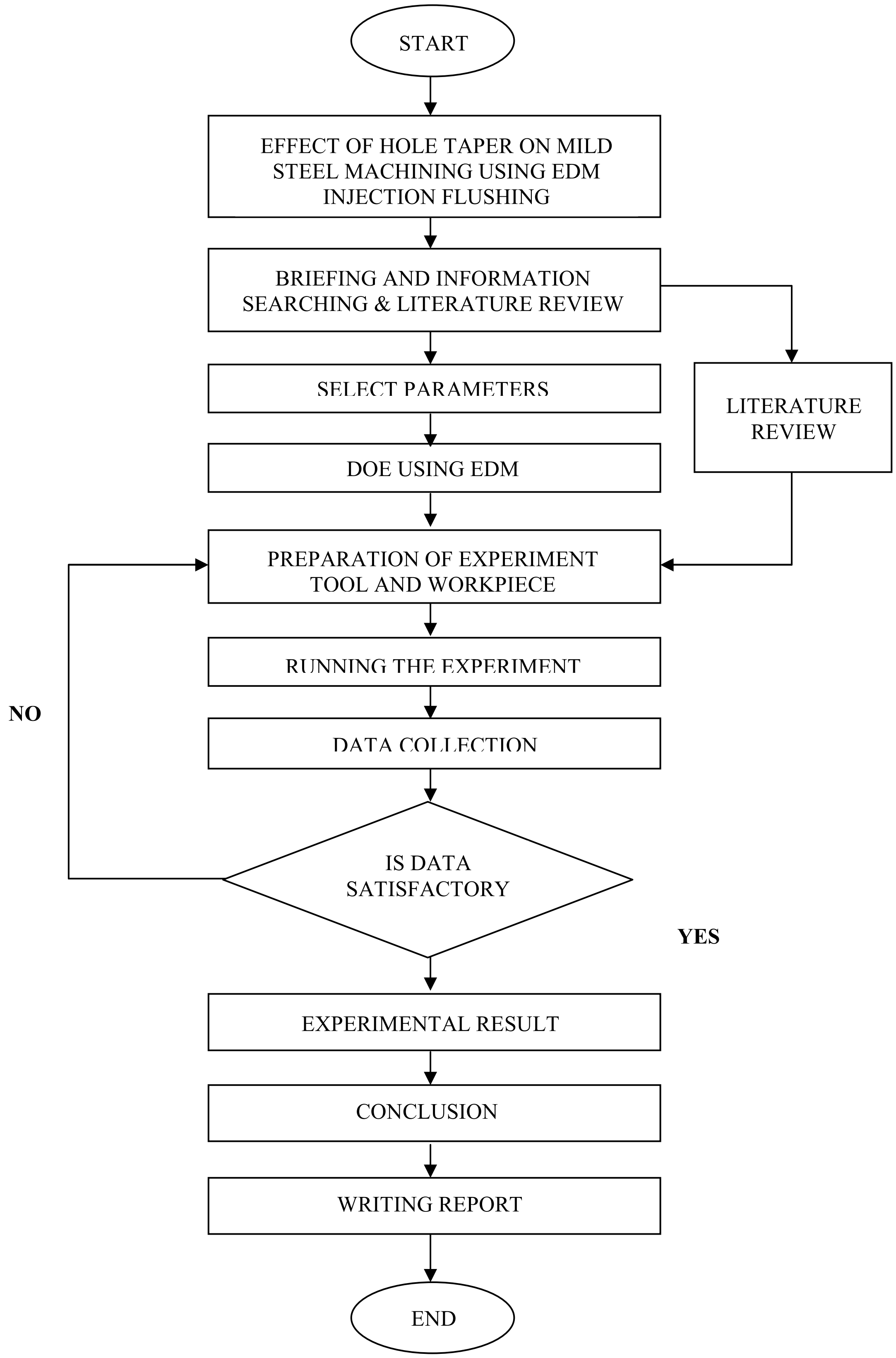

Figure 1.1: Research Flow Chart

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The requirement of industry regarding manufacturing of a component is very complex. This may be because of complexity of the job profile or may be due to requirements of higher dimensional accuracy with high surface finish. Efforts are being continuously made to overcome all of these problems. The basic principle of metal removal in the conventional methods of machining involves the use of tool, which is harder than the work piece and is subjected to wear. On the other hand, non conventional machining methods do not rely on direct contact between the tool and the work piece; hence the tool need not be harder than the job. Keeping these requirements into mind, a number of non-conventional methods have been developed. Research in areas related to non conventional machining has become a considerable interest due to the various advantageous offered by this process. Among the various non conventional machining processes, electrical discharge machine is the most widely and successfully used method for machining difficult to machine materials like tungsten carbide and super alloy. Good electrical conductivity is pre requisite for the fast machining of any material by EDM process.

2.2 Electrical Discharge Machining (EDM)

Electrical discharge machining, commonly known as EDM (also known as spark machining) is a process that is used to remove metal through the action of an electrical discharge of short duration and high current density between the tool and the work piece. EDM involves the removal of metal from a work piece by the erosive action of a controlled electrical spark to produce holes, slots and cavities. EDM has been an important manufacturing process for the tooling, mould and also in die industry making for several decades. The process is finding an increasing industrial use due to the ability of producing geometrically complex shape as well as its ability to machine hard materials that are extremely difficult to machine when using conventional process. According to Sommer (2000) EDM can be categorized into two: die sink EDM and Wire EDM. Die sinking EDM machines require the electrode to be machined in the exact opposite shape as the one in the work piece. Wire-cut EDM machines use a continuous wire as the electrode. However, EDM processes are classified into three main categories as shown in Figure 2.1 (Pandey and Shah, 1980).

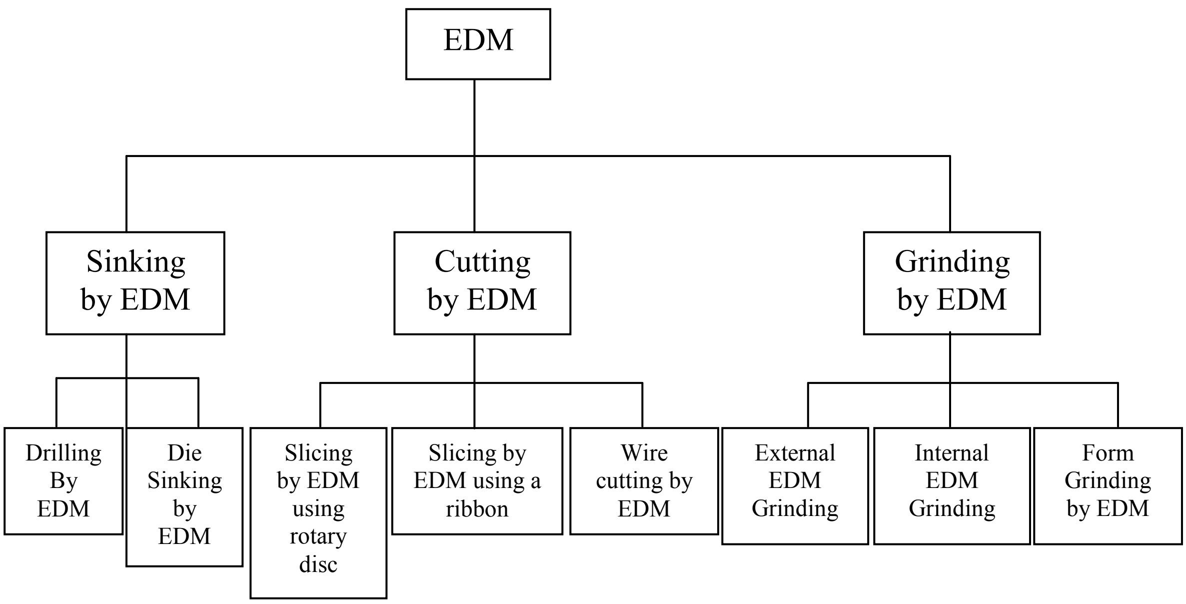

Figure 2.1: Classification of EDM processes

Source: (Pandey and Shah, 1980)

Conventional EDM, also known as sinker EDM and sometimes is also referred to as cavity type EDM or volume EDM (Sommer, 2000). Sinker EDM consists of an electrode and workpiece that are submerged in an insulating liquid such as oil or kerosene or other dielectric fluids. The electrode and workpiece are connected to a suitable power supply. The power supply generates an electrical potential between the two parts. A longer off time for example, allows the flushing of dielectric fluid through a nozzle to clean out the eroded debris, thereby avoiding a short circuit. These settings can be maintained in micro seconds. The typical part geometry is a complex 3D shape, often with small or odd shaped angles. Vertical, orbital, vectorial, directional, helical, conical, rotational, spin and indexing machining cycles are also used.

Most of EDM operation are conducted with electrodes which is have tool and work immersed in a liquid dielectric and mechanism of sparking is similar to that described expect that dielectric is contaminated with conductive particles. In EDM, material removal is achieved by preferential erosion of the work piece electrode as controlled discrete discharges are passed between the electrode and the work piece in dielectric medium as shown in Figure 2.2.

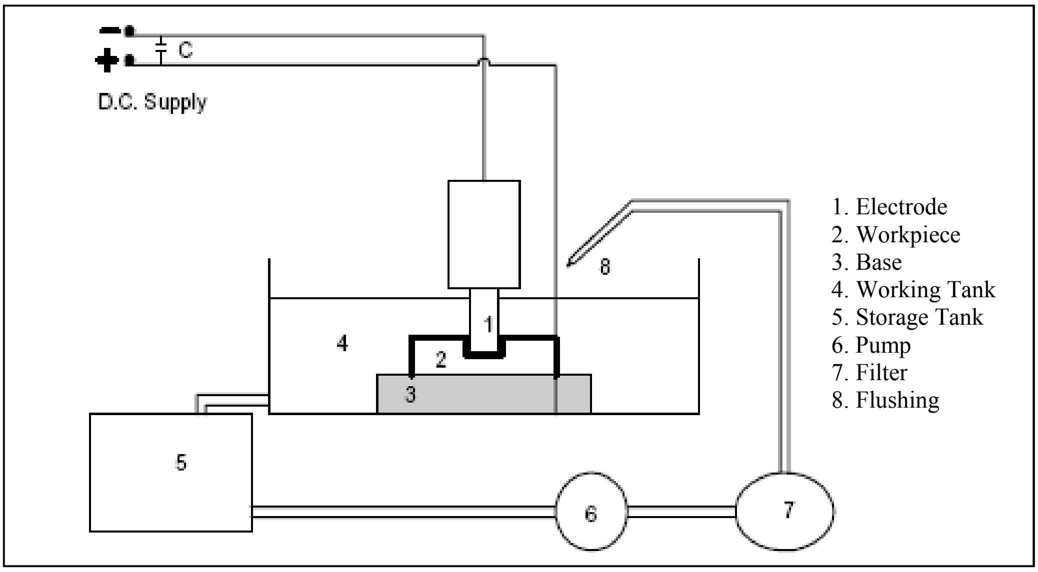

Figure 2.2 Schematic Diagram of EDM

Source: (Sommer, 2000)

Figure 2.3 shown that there is no direct contact between the electrode and the work piece, and no physical force is exerted (M.P Jahan, Y.S Wong, M. Rahman, 2009). The rate at which metal is removed is influenced by the electrical conductivity of the work piece and not by the material hardness. The shape of the hole will be identical to the shape of electrode. Schumacher, 2004 shows the three important phases as shown in figure 2.4 in electrical discharge procedure, preparation phase for ignition (a, b, c), phase of discharge (d, e, f), and interval phase between discharges (g, h, i).

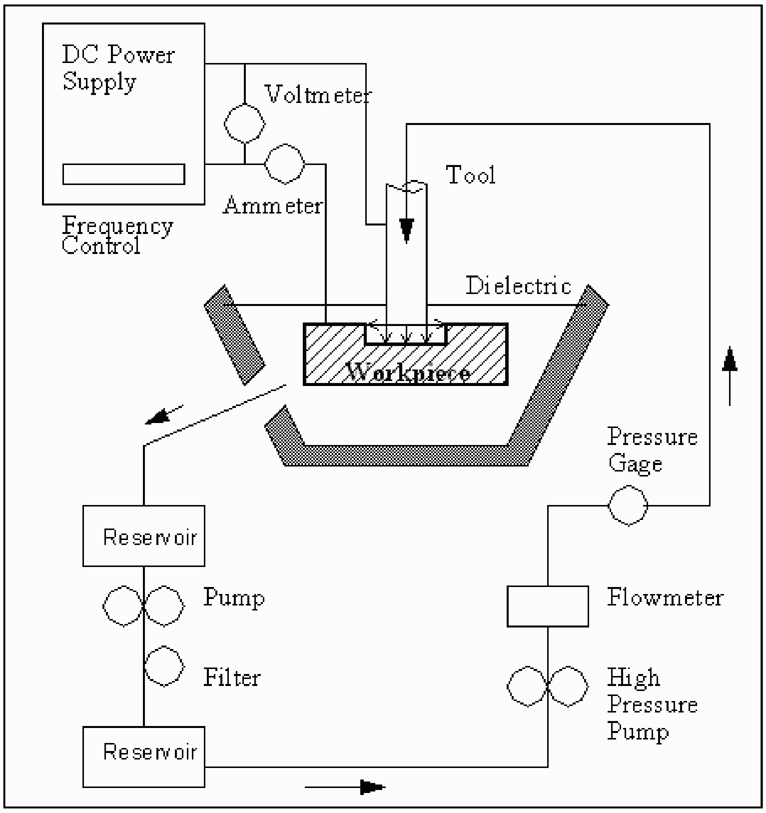

Figure 2.3: Basic EDM Systems

Source: (M.P Jahan, Y. S Wong, M. Rahman, 2009)